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ANNEALING EFFECTS IN FERROMAGNETIC AMORPHOUS ALLOYS(U)  
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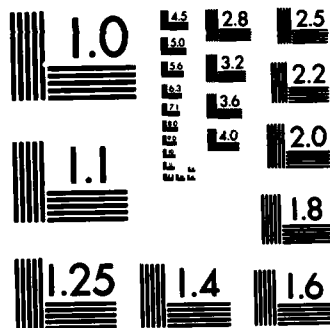
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ANNEALING EFFECTS IN FERROMAGNETIC AMORPHOUS ALLOYS

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ANNEALING EFFECTS IN FERROMAGNETIC AMORPHOUS ALLOYS

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We have carried out extensive measurements of annealing effects on the magnetic properties of low magnetostriction amorphous alloys, and have successfully interpreted the results in terms of a model based on the anisotropy of clusters of atoms in the amorphous state that can exist in a small number of stable configurations, with a corresponding number of different easy magnetic axes.

The experimental work has been mainly of two kind: torque measurements on disk samples, to follow the kinetics of the development and the reorientation of the induced anisotropy; and disaccommodation, or time-delay of permeability, measurements, to examine the effects of annealing on the low-field properties often dominated by domain-wall behavior.

The torque measurements on the reorientation of the easy axis confirm the experimental findings of Chamberon and Chamberod in France (Solid State Comm. 33 (1980) p 157), and lead to the conclusion that the reorientation does not occur by the continuous rotation of microscopic or macroscopic easy axes, but rather by the appearance of microscopic easy axes in some regions and their disappearance in other regions, without spatial correlation between the two regions. This is entirely consistent with a model in which local cluster of a few atoms can exist in a small number of energetically nearly equivalent states, each with a different easy magnetic axis. The clusters are visualized as consisting of eight to ten atoms, and our proposed model treats the clusters as imbedded in an isotropic elastic matrix. The rearrangement of the cluster does not take place by diffusion, and so the kinetics of the reorientation of the easy axis are not strongly affected by changes in the local structure that have large effects on the viscosity and the diffusivity.

The time-decay of permeability measurements are rather complicated, and do not lend themselves to a simple summary. The magnitude of the permeability decay depends strongly on the magnitude of the ac field used for the measurements, as

well as on the time and temperature of the annealing treatment. The largest effect occurs at a critical field called the stabilization field, which is associated with the unpinning of domain walls. Changes in the stabilization field with annealing are attributed to two major effects: stress relaxation, which is significant even in alloys with near-zero magnetostriction; and changes in the local induced anisotropy. For details, the reader can consult the published papers resulting for this work. However, an important practical result has emerged from our studies: by an appropriate annealing treatment in perpendicular field, the magnetization can be made to change by rotation rather than by domain wall motion, and the permeability decay or disaccomodation can be eliminated. The time-decay of permeability is a major practical problem in the engineering application of these alloys. The loss of permeability in some cases degrades the quality of the material significantly, and the fact that the properties change with time is highly undesirable. Therefore a practical method to eliminate the permeability decay may be of great engineering value.

The work through this reporting period has been mainly on zero-magnetostrictive alloys. This has been to avoid as much as possible the complication of the interaction of mechanical stress with the magnetostriction that can strongly influence magnetic properties, and also because the highest permeabilities and best practical magnetic properties are attained in zero-magnetostrictive materials. Zero-magnetostrictive alloys are a very special and expensive class, however, and our work is now beginning to include magnetostrictive alloys. This is of special interest to the Navy, in view of the strong development effect in magnetic transducers based on magnetostrictive effects that is carried out at the Naval Surface Weapons Center.

The group supported by this contract has published a number of papers, as given in the attached list. The numbering system is the same as that used in our letter report to D. K. Polk dated September 15, 1982.



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Publications Resulting from  
Contract N00014-80-C-0896; NR 039-204

1. Structure and Magnetism of Amorphous Alloys, T. Egami, IEEE Transactions on Magnetic, MAG-17 (1981) p 2600-05.
2. Kinetics of Formation of Induced Magnetic Anisotropy in a Zero-Magnetostriction Amorphous Alloy, Kai-Yuan Ho, P. J. Flanders, and C. D. Graham, Jr., J. Appl. Phys. 53 (1982) p 2279-81.
3. Physical Origin of Losses in Conducting Ferromagnetic Materials, C. D. Graham, Jr., J. Appl. Phys. 53 (1982) p 8276-80.
4. Isotropic Behavior of the Kinetics of Reorientation of Induced Anisotropy in an Amorphous Alloy, Kai-Yuan Ho, J. Appl. Phys. 53 (1982) p 7828-30.
5. Kinetics of Reorientation of Induced Anisotropy in Amorphous and Crystalline Alloys, Kai-Yuan Ho, J. Appl. Phys. 53 (1982) p 7831-33.
6. Kinetics of Changes in Initial Permeability Produced by Magnetic Annealing in a Zero-Magnetostrictive FeCoSiB Amorphous Alloy, T. Jagielinski, J. Appl. Phys. 53 (1982) p 7855-57.
7. Elimination of Disaccommodation in a Zero-Magnetostrictive FeCoSiB Amorphous Alloy, T. Jagielinski, J. Appl. Phys. 53 (1982) p 7852-54.
8. Structural Relaxation and Magnetism in Amorphous Alloys, T. Egami, J. Mag. Magn. Mat., to be published. (invited paper at Int. Conf. on Magnetism, Kyoto, Japan, 1982).
9. Single-Ion Anisotropy and Magnetostriction of Amorphous Alloys, T. Suzuki and T. Egami, J. Mag. Magn. Mat., to be published.

Closely related work not paid for by the ONR contract appears in:

A. Magnetic Aftereffect in Zero-Magnetostriction Amorphous Alloys, T. Jagielinski, J. Appl. Phys. 53 (1982) p 2282-84.